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# Science & Planning for a Low-Carbon Society: Electrified Transport

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US-China Electric Vehicles Forum, Beijing, China September 29, 2009

Renewable  
and Appropriate  
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Transportation  
Sustainability  
Research Center



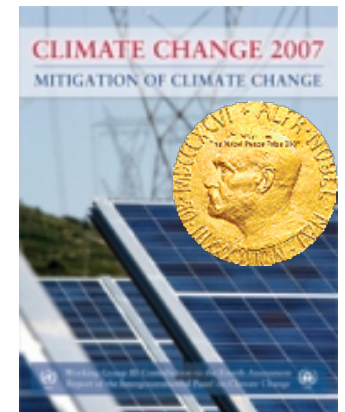
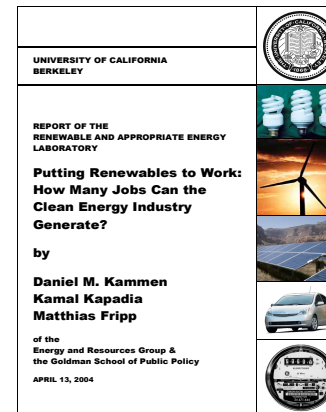
Switch: Transmission, Storage & End-Use  
Low-Carbon energy analysis and planning



TSRC: Transportation options, planning and systems  
science: EV/PHEV, biofuels, LCA



Energy &  
development  
- science  
- technology  
- economics  
- health  
- policies



**Minister Gang Wan provided us a challenge and a framework:**

- 1. Technology innovation (battery/drive train/supply)**
- 2. Technology roadmap**
- 3. Policy innovations (market mechanisms, life-cycle methods and legislation)**
- 4. Real-world implementation (working with customers, pilot projects, demonstrations, and market expansions)**

**Minister Gang Wan provided us a  
challenge and a framework:**

## **2. Technology roadmap**



# Technology Roadmap

([www.gigatonthrowdown.org](http://www.gigatonthrowdown.org))

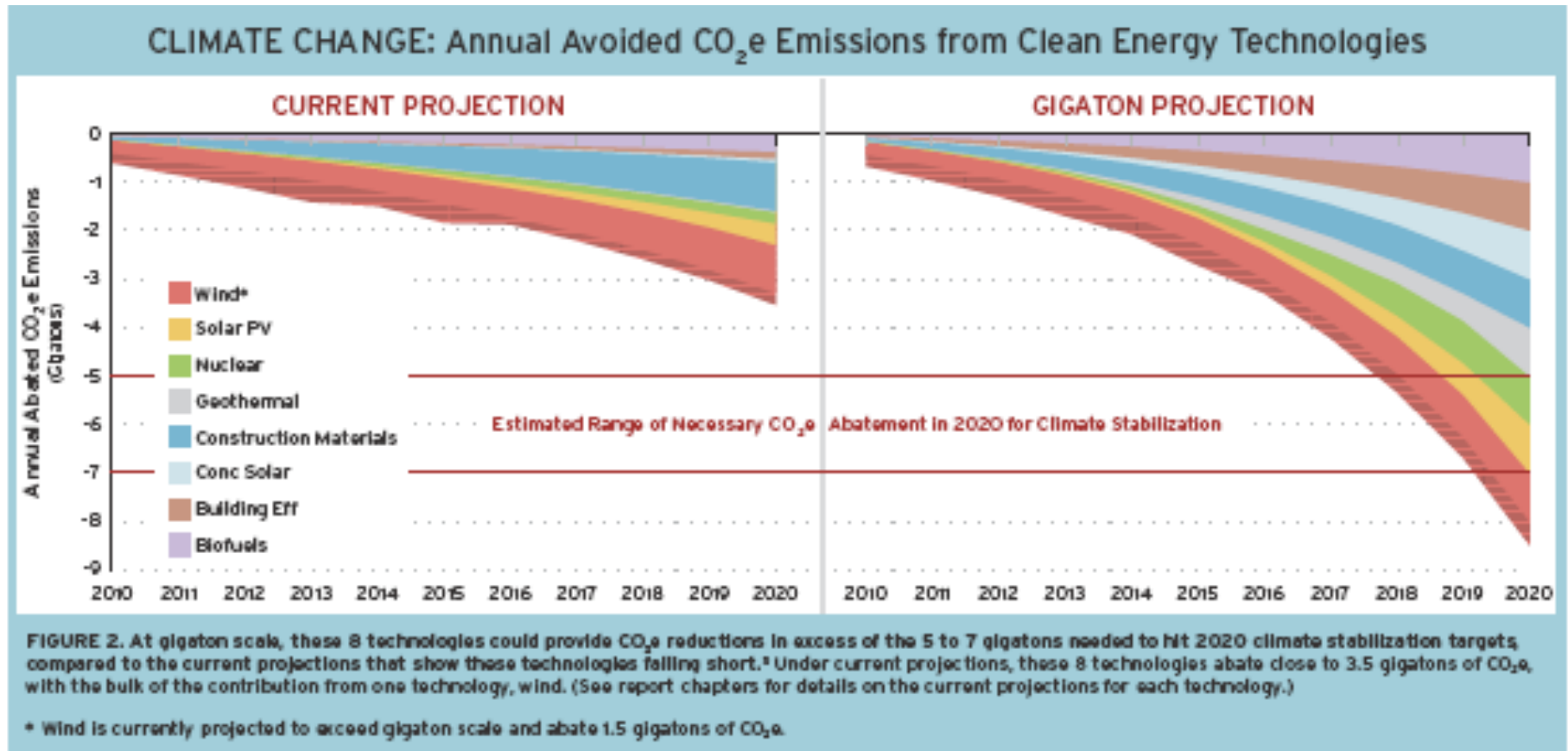
Project  
coordinator:  
**Sunil Paul**

Scientific advisor:  
**Dan Kammen**



**Next roadmap? GigatonChina**

# Technology Roadmaps



<http://www.gigatonthrowdown.org/>

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REPORT OF THE  
RENEWABLE AND APPROPRIATE ENERGY  
LABORATORY

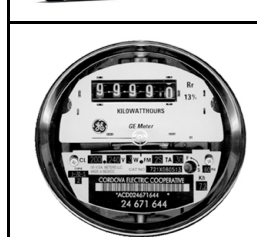
## Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?

by

**Daniel M. Kammen**  
**Kamal Kapadia**  
**Matthias Fripp**

of the  
Energy and Resources Group &  
the Goldman School of Public Policy

APRIL 13, 2004



# Green Jobs and the Clean Energy Economy

Co-authors  
Ditlev Engel,  
Chief Executive Officer  
Vestas Wind Systems A/S

Daniel M. Kammen,  
Professor and Co-Director,  
Berkeley Institute of the Environment



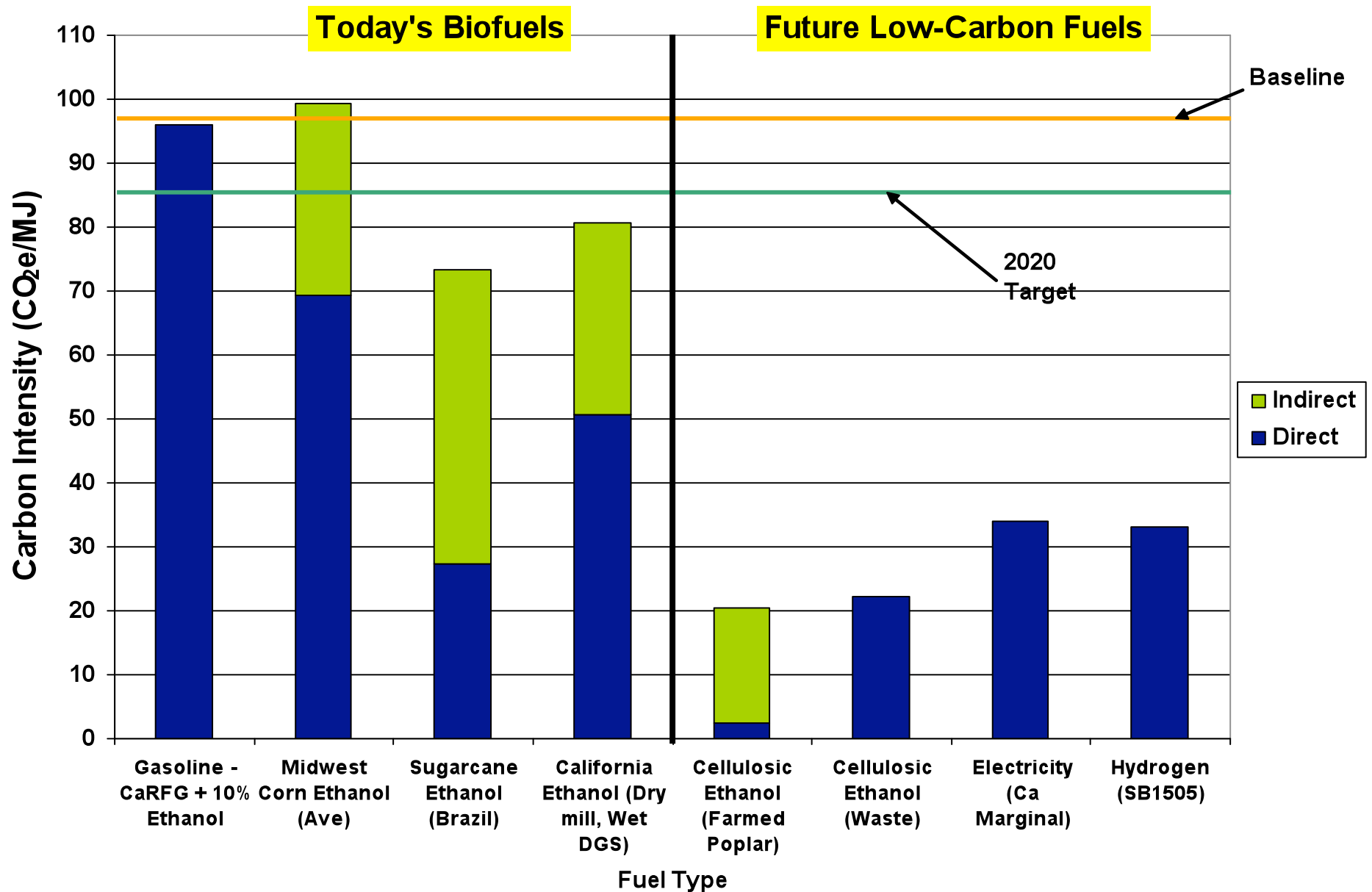
THOUGHT LEADERSHIP SERIES



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**3. Policy innovations (market mechanisms, life-cycle  
methods and legislation)**

# Carbon Intensity of Fuels



Searchinger, Kammen, Oppenheimer, Tilman, et al., *Science*, October 23, 2009, to appear.



# Energy Efficiency Strategies:

California PUC announces \$3.1 billion in energy efficiency projects on September 23, 2009



Residential New Construction - zero net energy by 2020; evolve to include vehicle charging as a new challenge



# The Switch Model:

Platform for geospatial and temporal analysis of low-carbon infrastructure

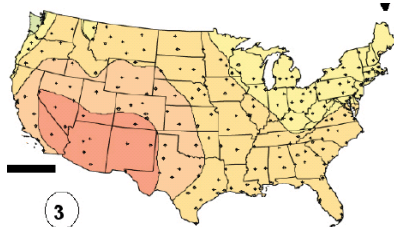
Combining resource data of existing infrastructure and renewables potential ...

Grid capacity & dynamics

Biomass & geo. resource quality

Wind resource quality

Solar resource quality  
 $\text{W m}^{-2}$



Plant-level view of existing US generation assets

397	Sayreville Cogeneration Facility	CC	CC	NG
398	Schering Corp Cogeneration aggregate	GT	NG	
399	Schuylkill Generating Station 1	ST	RFO	
400	Schuylkill Generating Station aggregate	GT	DFC	
401	Schuylkill Turbine GEN1	ST	NG	
402	Seaford Delaware Plant aggregate	ST	BIT	
403	Sewaren 1	ST	NG	
404	Sewaren 2	ST	NG	
405	Sewaren 3	ST	NG	
406	Sewaren 4	ST	NG	
...				

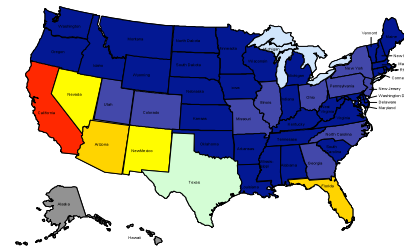
...leads to an estimate of the renewables build out and supply / demand balance in each region...

Investments for grid in 2030

Biomass Geo. generation in 2030

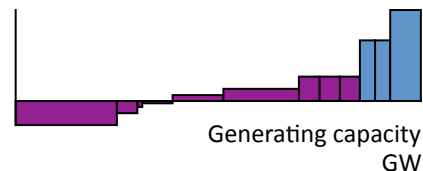
Wind generation in 2030

Solar generation in 2030  
TWh



Hour-by-hour view of price setting plant in each region

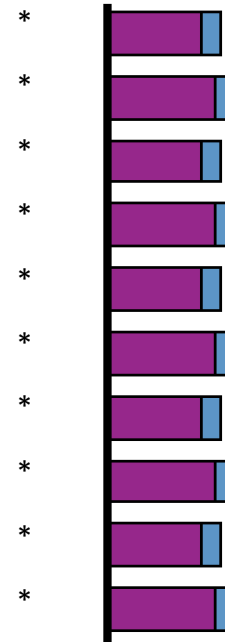
Generation cost  
\$ per MWh



...and estimates of future power prices

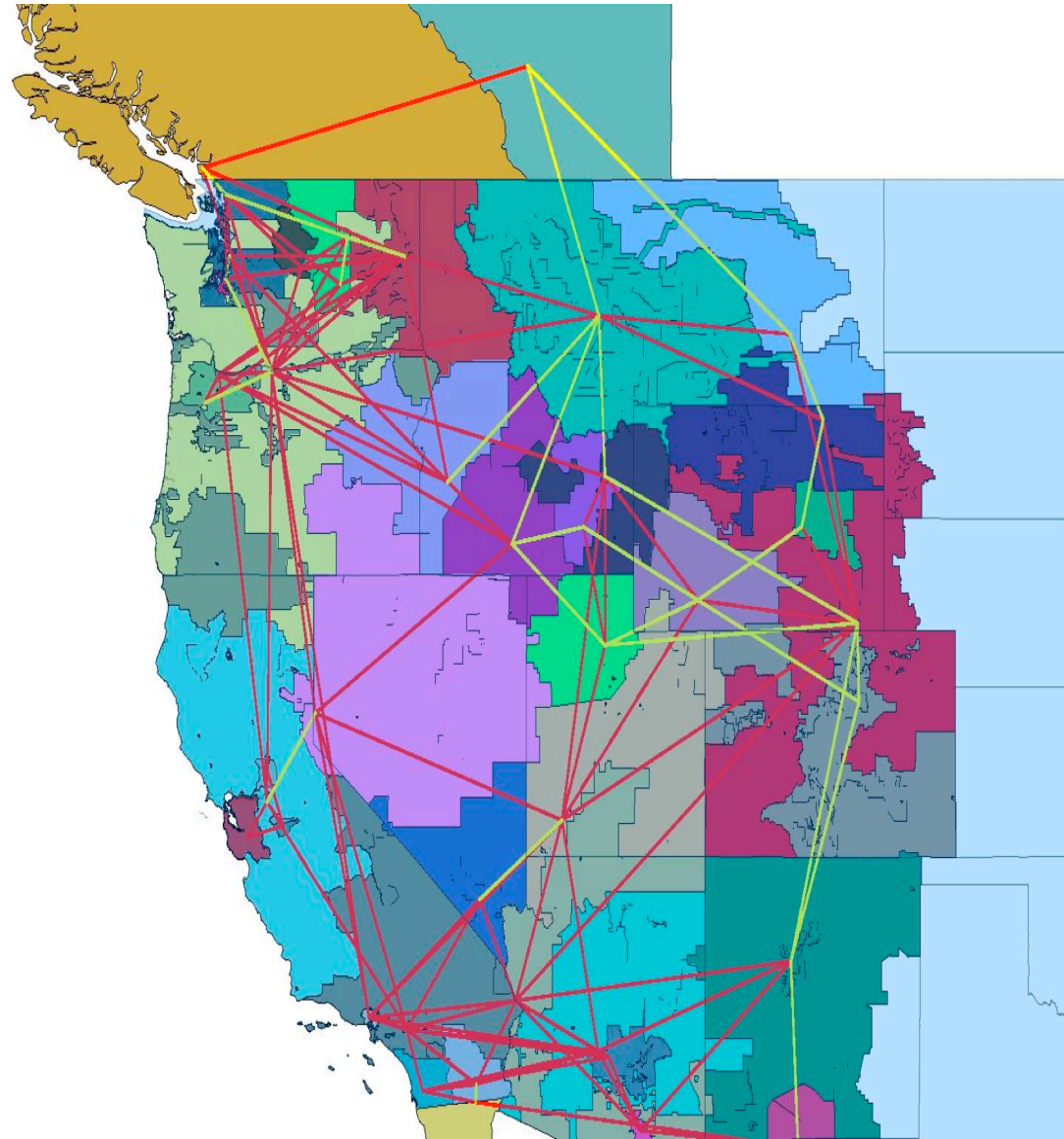
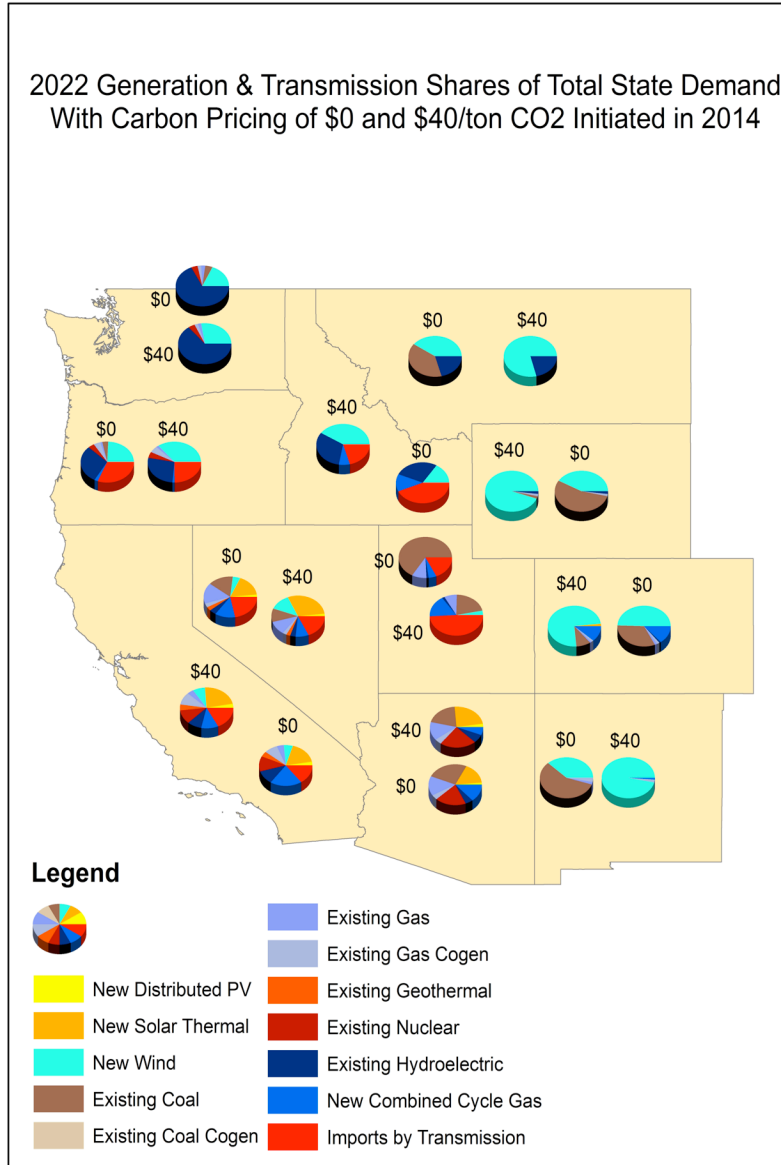
Retail power prices  
in 2030  
\$ per MWh

On peak  
Off peak





# SwitchWEST: Results for \$0 and \$20/tCO<sub>2</sub> in 2022



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**4. Real-world implementation (working with customers, pilot projects, demonstrations, and market expansions)**

# Virtual PHEV/EV Test Drive: Al Gore challenged us to include consumers as active partners

A RAEL/TSRC joint project in collaboration  
with the US Federal Energy Regulatory  
Commission (FERC) and CA ISO (grid  
operator)

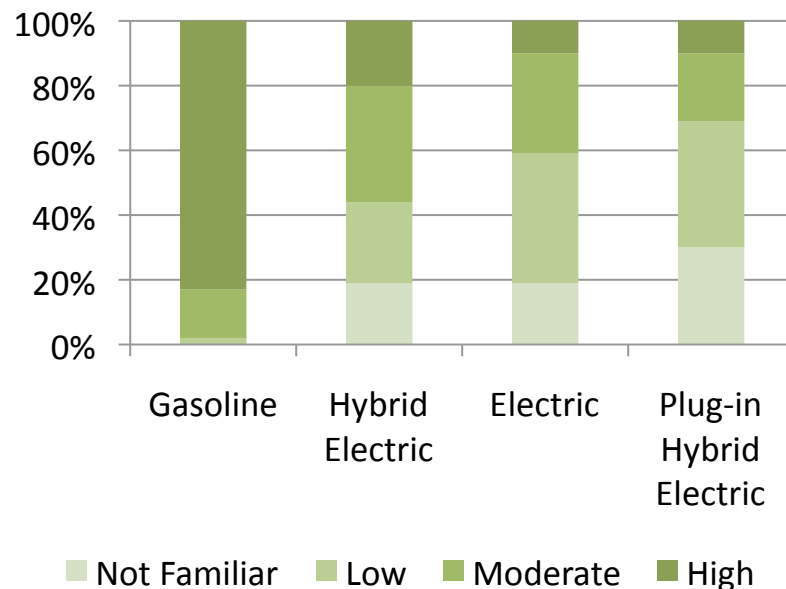
*...a device and web interface  
which allows citizens to take a  
virtual, three-month,  
personalized test drive in an  
electrified vehicle.*

-BYD e6-



# Lack of citizen experience could hinder PHEV/EV adoption

**Fig. 1: U.S. Consumer Survey: Stated Familiarity with Electrified Vehicles**  
(Axsen and Kurani 2008)



- A plug-in revolution will rely on citizens choosing a new way of buying and using their personal vehicle.
- This choice relies on citizens understanding the experience, pros, and cons of driving a plug-in vehicle. *This understanding lags, see Fig. 1.*
- Early research with potential buyers indicates that a test drive lasting several weeks may be the most impactful form of education.
- **Millions of test drives are prohibitively expensive.**



Gasoline: Hyundai Sonata



HEV: Toyota Prius



EV: Tesla Roadster



PHEV: Ford Escape

# Virtual PHEV/EV can provide a low cost, personalized, virtual test drive for millions

- Utilization of a cellular application/handheld device that fits a standardized diagnostic, and transmits drive-cycle and location data to a server which translates it into performance data for a variety of electrified vehicles.
- The users will visit a website to explore their own Virtual PHEV/EV day, finding out how much money and carbon dioxide they would have saved, where they would have run low on charge, and much more.
- The Virtual PHEV/EV program tracks aggregate data and correlate behavior, demographic, geography, PHEV vs. EV, and driving patterns with charging infrastructure needs and other conclusions useful to city leaders, electric grid utilities, charge station providers, and urban planners.

## Virtual PEHV/EV Project

